Triaxiality in neutron-rich odd-mass Y and Nb isotopes, the shape transitions and shape anticorrelation in Z = 39 – 45 odd-Z even-N nuclei

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Intensive investigations of shape transitions and coexistence in A ~ 100 neutron-rich nuclei have long been of importance [1,2]. Studies of triaxiality in Y and Nb isotopes, the neutron-rich nuclei with smaller Z in Z = 39 – 45, A ~ 100, and the shape transitions with regard to triaxiality in this important odd-Z region are of current interest [3,4,5].

New level schemes of $^{99,\ 101}$Y (Z = 39) and $^{101,\ 105}$Nb (Z = 41) based on the measurement of prompt gamma rays from the fission of ^{252}Cf at Gammasphere were interpreted by the triaxial-rotor-plus-particle model calculations [5]. The model calculations were performed to reproduce the level excitations, signature splittings and branching ratios of the observed bands in Y and Nb isotopes. The fitted parameters including triaxiality and quadrupole deformations are summarized in Table I.

Table I Model calculation parameters for Y & Nb isotopes

Nucleus & bands	Quadrupole defor. ε_2	Triaxiality γ (deg.)	Coriolis attenua.ξ	Inertial para. $E(2^+)$ (MeV)
^{99}Y band 1	0.41	0	1.0	0.14
^{101}Y band 1	0.39	0	0.95	0.16
^{101}Nb band 1	0.35	-19	0.83	0.2
band 2	0.25	-5	1.0	0.13
band 3	0.25	-5	1.0	0.13
^{103}Nb band 1	0.37	-15	0.8	0.155
^{105}Nb band 1	0.36	-13	0.8	0.16

* Data in level scheme of ^{103}Nb are taken from [6].

As can be seen in Table I, the model calculations strongly support a pure axially-symmetric shape with large quadrupole deformation, $\varepsilon_2 = 0.41$, $\gamma = 0^0$ and $\varepsilon_2 = 0.39$, $\gamma = 0^0$ in the $5/2^+[422]$ ground-state band (band 1 in Table I) of odd-Z, even N isotopes ^{99}Y and ^{101}Y isotopes, respectively.

However, the model calculations reproducing the data yielded small γ values ranging from -19^0 to -13^0 for the $5/2^+[422]$ ground-state bands (band 1) of $^{101,\ 103\ 105}$Nb and a γ value of -5^0 for the two negative-parity bands ($3/2^-[301]$, band 2, and $5/2^-[303]$, band 3) in ^{101}Nb. Considering the γ values near -30^0 obtained for Tc (Z = 43) and Rh (Z = 45) isotopes in our previous work [4,5], the Nb isotopes are considered to be transitional nuclei regarding triaxial deformation in this odd-Z, even-N nuclear region.

Combining the deformations obtained for Rh, Tc and Nb, Y isotopes, an anticorrelation of quadrupole deformation and triaxiality is seen in these neutron-rich odd-Z nuclei with Z ranging from 39 to 45 (see Fig. 1). Due to the large neutron number N, the 'quasimagic' Z = 40 does not manifest itself. However, the deformed shell gap at Z = 38 plays an important role when Z decreases from Z = 45 to 39, causing an increase in quadrupole deformation. When Z decreases from 45 to 39, the nuclear shape changes from nearly maximum triaxiality in Rh to axial symmetry in Y isotopes.

One may conclude that in the A ~ 100 neutron-rich nuclei triaxial shape is prevalent for the bands based on a one-quasiparticle $g_{9/2}$ proton state in the region with Z > 41.

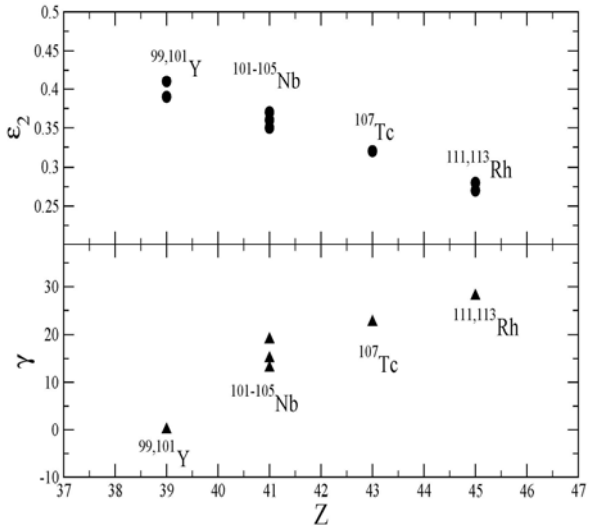

FIG. 1: Systematics of triaxial and quadrupole deformations observed in the neutron-rich odd-Z = 39, 41 , 43, 45 even-N isotopes. Data of Tc and Rh isotopes are taken from our previously reported paper [3] and [4], respectively.

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